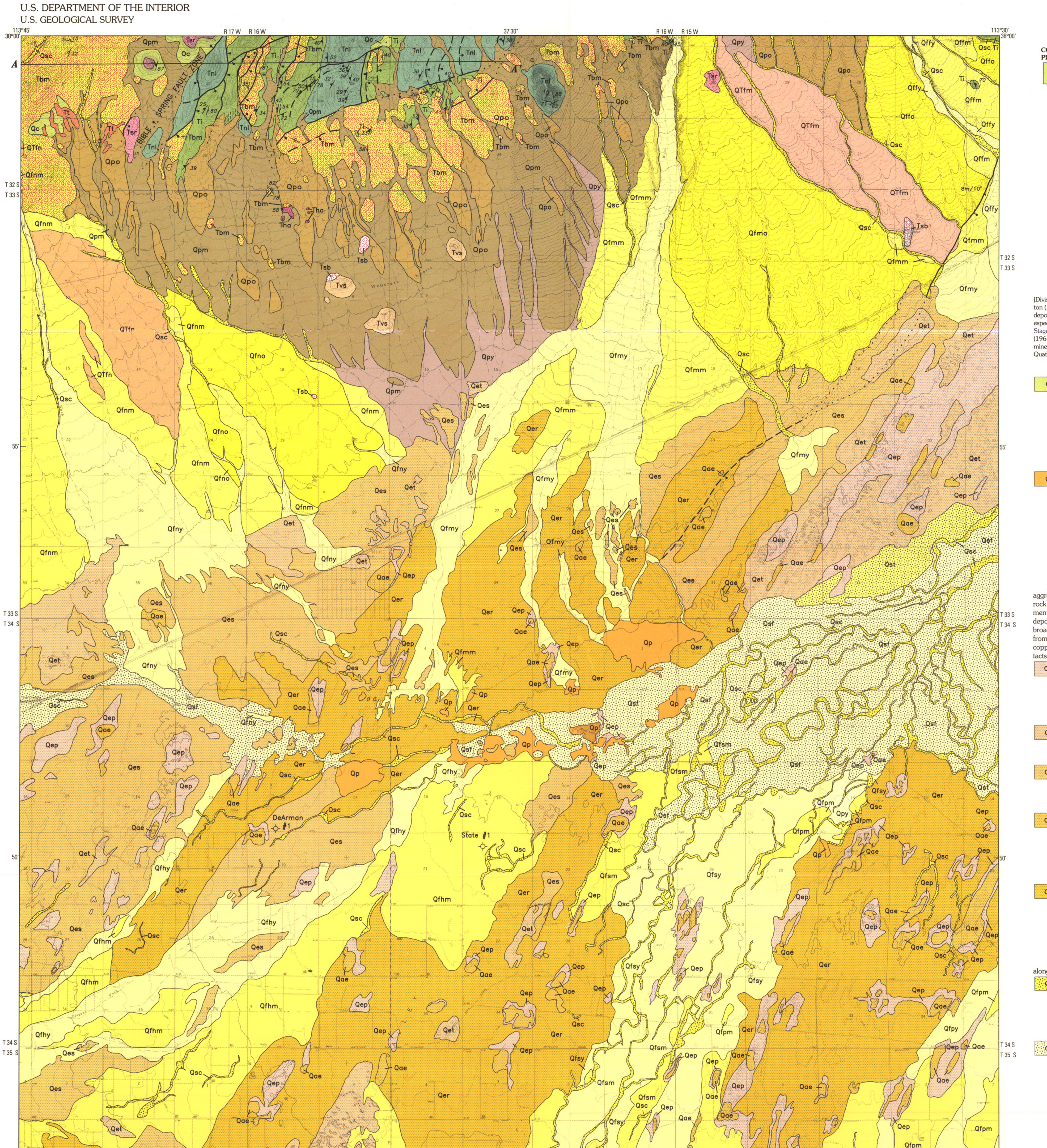

Base from U.S. Geological Survey, 1:24,000, 1972, Beryl, Clark Farm, Yale Crossing, Zane. Projection: Utah coordinate system, south zone (Lambert conformal conic). 1927 North American datum

SCALE 1:50 000

CONTOUR INTERVAL 5 FEET (Except Beryl quadrangle, 20 feet)
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped in 1990–91 by Van S. Williams, assisted in 1991 by Steven Flock
Edited by Alessandro J. Donatich
Color design by Denny Welp
Graphic design by Patricia L. Wilber
Cartography by Henry Williams
Manuscript approved for publication May 22, 1995

CORRELATION OF MAP UNITS

COLLUVIUM AND PLAYA DEPOSITS: Qc, Qp — EOLIAN DEPOSITS: Qep, Qet, Qes, Qae, Qer — STREAM ALLUVIUM: Qsc, Qsf, Qst — PIEDMONT-SLOPE ALLUVIUM: Qpy, Qpm, Qpo — ALLUVIAL-FAN DEPOSITS: Qffy, Qfmy, Qfny, Qfhy, Qfsy, Qfpy; Qffm, Qfmm, Qfnm, Qfhm, Qfsm, Qfpm; Qffo, Qfmo, Qfno, Qfso; QTfm, QTfn — Holocene, Pleistocene, Pliocene — QUATERNARY

Unconformity

VOLCANIC AND SEDIMENTARY ROCKS: Tvs, Tsb, Tsr, Tt, Tbm, Tha, Ti, Tnl — Miocene, Oligocene — TERTIARY

DESCRIPTION OF MAP UNITS

[Divisions of Pleistocene time are from provisional ages reported in Richmond and Fullerton (1986). Age assignments for surficial deposits are based chiefly on the degree of post-depositional modification of original surface morphology and degree of soil development, especially the morphology and thickness of calcium carbonate-enriched soil horizons. Stages of soil-carbonate morphology correspond to those described by Gile and others (1966). Dry colors of the less-than-2-mm size fraction of surficial deposits were determined by comparison with Munsell Soil Color Charts (Munsell Color, 1973). Contacts of Quaternary units are approximately located]

COLLUVIUM AND PLAYA DEPOSITS

Qc **Colluvium and residuum (Holocene and upper Pleistocene)**—Hill-slope deposits of unsorted, unstratified, angular, light-gray to reddish-brown volcanic pebbles, cobbles, and boulders as large as 50 cm in diameter in a matrix of reddish-brown angular sand. The clasts weathered out from bedrock, then moved downslope through creep and slopewash and accumulated on hill slopes. Mapped only where the deposits completely obscure underlying bedrock. Primarily mantles soft rhyolite tuffs and related clastic deposits (Tt) where unit Tt is overlain by resistant rocks of the mafic lava-flow member of the Blawn Formation (Tbm) or the rhyolite lava-flow member of the Steamboat Mountain Formation (Tsr). Thickness less than 5 m

Qp **Playa deposits (Holocene and upper Pleistocene)**—Fine-grained, tan, clayey, silty, and sandy gypsiferous and calcium carbonate-rich deposits that accumulated in ephemeral lakes in shallow closed basins. Closed basins formed as blowouts that are ringed by dunes or formed where moving dunes blocked small streams. A sample from the top of a 1-m-thick bed from NW1/4SE1/4 sec. 24, T. 35 S., R. 16 W., just south of map area, contains 68 percent gypsum and 6 percent calcium carbonate (G.E. Christenson, Utah Geological Survey, unpub. data, 1987). Contacts are gradational and approximately located. Thickness at least 3 m

EOLIAN DEPOSITS

Eolian deposits are made up of loose, sand-size sediment that consists of soil aggregates cemented by calcium carbonate, of crystal fragments, and of volcanic rock fragments that have been transported and redeposited by wind. The sediment is locally derived from adjacent deflation basins eroded in older alluvial deposits or from young unvegetated sediment deposited by sheet flow along broad, shallow stream courses. Eolian deposits extend north-northeastward from their sediment sources. Includes active and relict parabolic, transverse, and coppice dunes, and also some deposits in deflation basins between dunes. Contacts are gradational and approximately located

Qep **Windblown sand in parabolic dunes (Holocene)**—Highly curved dunes whose longest dimension is parallel to the prevailing wind direction and whose center extends much farther downwind than dune horns, which are concave into the wind. This is the most common and largest dune in the Escalante Desert. Dunes reach heights of 5 m on crest of parabola and decrease in height along flanks; a deflation basin commonly occurs in center of parabola. Maximum thickness about 5 m

Qet **Windblown sand in transverse dunes (Holocene)**—Small dunes that have their longest dimension transverse to the wind direction and that have relatively little curvature. Commonly found along flanks of large fields of parabolic dunes. Maximum thickness about 5 m

Qes **Windblown sand in coppice dunes and sheets (Holocene)**—Small accumulations and thin sheets that lack well-developed dune form. Common where sand collects around vegetation in areas of limited sand supply or where flowing water periodically reworks incipient dunes. Maximum thickness about 1 m

Qae **Deflation basin sediment (Holocene)**—Sandy deposits in deflation basins and lag material from underlying reworked alluvium. Includes windblown sand and sand-size aggregates, which are fragments of a calcic soil horizon that formed at depths of 0.5–2 m and from which the overlying loose sand and silt was stripped. Also includes minor lacustrine material (Qp) deposited by occasional ponds of water in the basin. Contacts are gradational and approximately located. Maximum thickness about 0.5 m

Qer **Windblown sand in relict dunes (Holocene and Pleistocene)**—Extensive, vegetation-covered, low ridges of sand that are elongate in a north-northeast direction. These features are coalesced former parabolic dunes that stabilized and lost form and height through sheetwash erosion. Maximum thickness about 3 m

STREAM ALLUVIUM

Silt, sand, and gravel that fill channels and form floodplains and terraces along streams

Qsc **Stream-channel alluvium (Holocene)**—Channel alluvium of ephemeral streams. Very pale brown (1 YR 7/3), moderately bedded and poorly sorted pebbly sand and silt, intercalated with lenticular beds of channel-crossbedded, sandy and pebbly cobble gravel. Contains bars and bed forms that were deposited in active stream channels. Unit also includes alluvium and colluvium in small fans along valley sides. Maximum thickness about 3 m

Qsf **Stream-floodplain alluvium (Holocene)**—Alluvium of abandoned stream channels overlain by overbank and sheetwash deposits of laminated fine sand and silt. Deposited near the center of the Escalante Desert basin in topographic lows between large coalesced alluvial fans. Floodplains are broad, having low banks and gentle gradients, and they commonly lack a distinct channel. Floodplain surface is commonly mud-cracked silty sand (bare except for scattered bushes) that lacks soil development. Floodplains are commonly covered with a semi-braided pattern of relict stream channels and are pitted with blowout depressions and mantled with eolian deposits. Where floodplains belong to streams in mountain canyons or streams entrenched in alluvial-fan complexes, they may have slight soil development that consists of a thin surface horizon darkened by organic material. Unit may include small stream channels and small alluvial fans along valley sides. Deposits as high as 4 m above stream-channel bottoms. Surface of unit slopes downstream less than 1°. Maximum thickness 4 m

Qst **Stream-terrace deposits (upper Pleistocene)**—Stream-channel deposits overlain by floodplain deposits and thin eolian deposits of silt and sand. Pebbles of volcanic rock form desert pavement on 40–80 percent of surface of deposit. Subsoil moderately indurated by pedogenic calcium carbonate. Deposits are about 1 m above the usual level of flood deposition and are subject to modification by other processes such as soil formation, sheetwash erosion, and eolian deposition. Exposed only in east-central part of map area. Thickness 4 m

PIEDMONT-SLOPE ALLUVIUM

Poorly to moderately sorted, thin, fan-shaped deposits of sand, gravel, and silt that form small coalesced alluvial fans and that cover pediments in those parts of the piedmont slope not subject to alluvial-fan deposition by a major stream. Deposits grade from sandy gravel containing cobbles and boulders proximal to the mountain front, to distal gravelly sand, silt, and clay

Qpy **Young piedmont-slope alluvium (Holocene and upper Pleistocene)**—Young deposits on active depositional surfaces on lower part of piedmont slope. Includes modern alluvium of small ephemeral streams and, in places, colluvium, sheetwash, and talus. Undissected and has no significant soil horizon development. Maximum thickness at least 2 m and probably 8 m

Qpm **Middle piedmont-slope alluvium (upper and middle Pleistocene)**—Broad, slightly dissected sheets of alluvium that cover middle part of piedmont slopes and that mantle inactive pediment surfaces. Lower parts of unit may be buried locally by thin sheetwash deposits. From 0.5–2 m below surface of deposit, a moderately to strongly developed calcium carbonate-enriched soil horizon (stage II–III) has formed. Maximum thickness at least 3 m and probably 8 m

Qpo **Old piedmont-slope alluvium (middle and lower Pleistocene)**—Isolated remnants of alluvium mantling inactive pediment surfaces on upper part of piedmont slopes. Strongly developed calcic soil has been stripped down to a laminar calcium carbonate horizon (stage IV). Maximum thickness at least 2 m and probably 4 m

ALLUVIAL-FAN DEPOSITS

Poorly to well sorted, thick, extensive, fan-shaped deposits of alluvium that extend across the floor of the Escalante Desert from points where major streams emerge from the mountains surrounding the desert basin. Deposits grade from sandy gravel containing cobbles and boulders proximal to the mountain front, to distal gravelly sand, silt, and clay. Deposits are divided into four age groups: young, middle, older, and oldest. The age groups are further subdivided according to the drainage area that is the primary source of the sediment, because each of the drainage areas have distinctive geomorphic histories and rock types. Fourmile Wash is in northeastern part of map area, Mountain Spring Wash in northern, Negro Liza Wash in northwestern, Hogans Wash in western, Shoal Creek in southern, and Pinto Creek in southeastern. In upper part of fans, lithology of cobbles clearly reflects rocks in source area, but near the center of the Escalante Desert basin, cobbles are absent and sediment of coalesced fans is distinguished primarily by geomorphic position

Young alluvial-fan deposits (Holocene and upper Pleistocene)—Sand and subordinate pebble gravel, silt, and clay in active alluvial fans fed by major drainage basins. Surface is not entrenched by streams but grades up the fan slope to channel and floodplain alluvium of modern streams that are generally entrenched into older fan alluvium. Deposits generally lie on distal margins of large, multi-generational alluvial-fan complexes and extend into the center of the Escalante Desert or terminate against the side of older fans. Deposits commonly fill broad, shallow valleys on fan surfaces so that the outcrop pattern is more linear than fan shaped. Unit grades into floodplain alluvium near fan toes. Contacts are gradational and approximately located. No distinctive soil horizons have developed, and surface is covered with sand or silt. Maximum thickness at least 3 m and probably 10 m

- **Qffy** Young fan alluvium of Fourmile Wash
- **Qfmy** Young fan alluvium of Mountain Spring Wash
- **Qfny** Young fan alluvium of Negro Liza Wash
- **Qfhy** Young fan alluvium of Hogans Wash
- **Qfsy** Young fan alluvium of Shoal Creek
- **Qfpy** Young fan alluvium of Pinto Creek

Middle alluvial-fan deposits (upper to middle Pleistocene)—Sand, silt, and gravel occurring as slightly dissected remnants of alluvial fans. This generation of alluvial-fan deposits makes up most of the area of the fan complexes, and may include multiple phases of deposition. Consists of 1- to 1.5-m-thick beds of sandy alluvium that overlie beds of interbedded sand and crossbedded gravel. Deposits become finer grained down slope. Near distal margins of fans, material in upper 1–2 m of unit is chiefly fine sand and silt and contains a substantial eolian component of sand and loess. From 0.5–2 m below surface of deposit, a moderately to strongly developed calcium carbonate-enriched soil horizon (stage II–III) has formed. Locally, unit has been extensively reworked by wind and sheetwash; deflation has locally removed upper soil horizons and exposed lower horizons of pedogenic calcium carbonate. Contacts are gradational and approximately located. Maximum thickness probably about 100 m

- **Qffm** Middle fan alluvium of Fourmile Wash
- **Qfmm** Middle fan alluvium of Mountain Spring Wash
- **Qfnm** Middle fan alluvium of Negro Liza Wash
- **Qfhm** Middle fan alluvium of Hogans Wash
- **Qfsm** Middle fan alluvium of Shoal Creek
- **Qfpm** Middle fan alluvium of Pinto Creek

Older (middle to lower Pleistocene) and oldest (lower Pleistocene to Pliocene) alluvial-fan deposits—Sand and gravel in dissected remnants of alluvial fans that are geomorphically higher than middle fan alluvium (Qffm, Qfmm, Qfnm, Qfhm, Qfsm, Qfpm). Includes at least two phases of deposition. Unit has a strongly developed laminar calcium carbonate-enriched soil horizon (stage III–IV) that is extensively exposed at the surface because of erosional stripping of upper soil horizons. Generally exposed in discontinuous remnants that extend radially outward near the fan head and are about 2 m above the surrounding younger fan deposit. Comprises most of the thickness of the Tertiary-Quaternary basin-fill deposits, which attain a thickness of 567 m in State #1 drill hole near center of map area

- **Qffo** Older fan alluvium of Fourmile Wash (middle to lower Pleistocene)
- **Qfmo** Older fan alluvium of Mountain Spring Wash (middle to lower Pleistocene)
- **Qfno** Older fan alluvium of Negro Liza Wash (middle to lower Pleistocene)
- **Qfso** Older fan alluvium of Shoal Creek (middle to lower Pleistocene)
- **QTfm** Oldest fan alluvium of Mountain Spring Wash (lower Pleistocene to Pliocene)
- **QTfn** Oldest fan alluvium of Negro Liza Wash (lower Pleistocene to Pliocene)

VOLCANIC AND SEDIMENTARY ROCKS

Tvs **Silicified volcanic rocks (Miocene)**—Mostly pale yellow brown but locally white to red, hydrothermally altered and highly silicified volcanic rocks exposed only in four isolated outcrops about 3 km south of range front. Upper part is very resistant to erosion and caps small buttes. Overlies the basalt member of the Steamboat Mountain Formation (Tsb) and may be part of the Steamboat Mountain Formation, but original composition and texture are completely obscured by intense silicification. No other volcanic rocks younger than Steamboat Mountain Formation have been found within 25 km of these outcrops. Thickness 60 m

Steamboat Mountain Formation (middle Miocene)—Bimodal assemblage of high-silica rhyolite and basaltic trachyandesite (IUGS classification of Le Maitre, 1989) that has isotopic ages between 13 and 10 Ma (Best, 1987; Best, Morris, and others, 1987; Best, Mehnert, and others, 1987). Deposits are mostly flat lying and unfaulted, and locally unconformably overlie tilted older units. First recognized and described northwest of map area

Tsb **Basalt member**—Dark-gray to black, aphyric to weakly porphyritic lava flows that consist of olivine and augite phenocrysts and sparse quartz xenocrysts in a glassy to microcrystalline matrix of plagioclase, augite, and Fe-Ti oxides. Outcrop near Modena Draw Reservoir, 12 km west of southwest corner of map area, has a whole-rock K-Ar age of 10.8±0.6 Ma (Best and others, 1980). Exposed only in four small isolated knolls south of mountain front. Base not exposed. Maximum exposed thickness in map area about 3 m. Maximum thickness estimated at 120 m where better exposed north of map area (Best, 1987)

Tsr **Rhyolite lava-flow member**—Light-gray, pale-pink, and pale-purple lava flows. Mostly massive, aphanitic, and slightly porphyritic, but locally vitrophyric and flow layered, and in a few places rocks contain small (less than 1 cm in diameter) spherulites, irregularly shaped vugs, and lithophysae. Vugs and lithophysae commonly contain vapor-phase quartz and topaz less than a few millimeters long. Some rocks are virtually aphyric but most contain as much as 30 percent phenocrysts of smoky quartz, sanidine, sodic plagioclase, and rare biotite. Fresh flow rock is uniformly high-silica, high-alkali rhyolite having K-Ar and fission-track ages of 13–12 Ma (Best and others, 1991; Kowallis and Best, 1990). Exposed only in four outcrops capping hills in northwestern part of the map area. About 130 m thick at north margin of map area. Total thickness at Steamboat Mountain, just northwest of map area, is about 500 m (Best, 1987)

Tt **Rhyolite tuffs and related clastic deposits (Miocene)**—Heterogeneous sequence of pyroclastic and minor epiclastic deposits associated with the rhyolite lava-flow member (Tsr) of the Steamboat Mountain Formation (13–12 Ma) and the rhyolite member of the Blawn Formation (22–18 Ma), which is exposed north and west of map area (Best, 1987; Best, Grant, and others, 1987; Best, Morris, and others, 1987). Colluvium (Qc) and talus from resistant rocks of the overlying Steamboat Mountain and Blawn Formations commonly conceal the soft rocks of this unit. Near northwest corner of map area, a few beds are exposed in ledges. Elsewhere the unit does not crop out but can be traced from pebble- and cobble-size pieces in colluvium. Unit is most commonly a light-gray to pale-yellow-brown, partially welded, crystal-poor ash-flow tuff that contains sparse phenocrysts, less than 2 mm in diameter, of quartz, feldspar, and sparse biotite. Unit also contains variable quantities of dark lithic fragments of Miocene rhyolite flow rocks and of older welded tuffs of the Bauers Tuff Member of the Condor Canyon Formation (exposed just west of map area), Isom Formation, and Lund Formation. Unit includes bedded, reworked pyroclastic and epiclastic deposits that consist of light-brown to light-gray, crudely stratified and sorted sandstone and minor siltstone that locally contain cobbles of welded tuff (Lund Formation) and beds of red, poorly sorted, angular volcanic debris of sand to cobble size. Thickness 100–300 m

Blawn Formation (lower Miocene)—An assemblage of high-silica rhyolite and trachyandesite rocks (IUGS classification of Le Maitre, 1989) first recognized and described north and west of map area that have isotopic ages ranging between 24 and 18 Ma (Best, 1987; Best, Mehnert, and others, 1987; Willis and others, 1987). In those areas, unit consists of informal members of rhyolite tuff, rhyolite lava flows, rhyolite intrusions, mafic lava flows, and minor epiclastic deposits. Only the mafic lava-flow member occurs in map area

Tbm **Mafic lava-flow member**—Massive, locally vesicular, porphyritic lava flows that have lisegang bands and weather red brown. Phenocrysts of plagioclase and pyroxene lie in a gray to black microcrystalline, locally glassy, matrix. Composition of flow rocks ranges from 55 to 60 weight percent SiO_2 and 2.4 to 4.0 percent K_2O (Best, 1987). On east flank of the Wah Wah Mountains northeast of map area, the basal flow in this unit (in about the same stratigraphic position) has a whole-rock K-Ar age of 23.2±1.0 Ma (Abbott and others, 1983). Map unit locally includes small unmapped outcrops of underlying hornblende andesite lava flows (Tha). Maximum thickness about 160 m

Tha **Hornblende andesite lava flows (Miocene)**—Aphyric to generally weakly porphyritic lava flows and minor intercalated autoclastic breccias. Colors range from reddish brown to black. Characteristic acicular black hornblende phenocrysts are as much as 1 cm long and show a strong preferred orientation that imparts a foliation and, locally, a lineation to the rock. Other, less abundant, phenocrysts are plagioclase, pyroxene, and biotite. Exposed only in a few isolated knolls south of mountain front and as small unmapped outcrops within the mafic lava-flow member (Tbm) of the Blawn Formation. Base is not exposed. Exposed thickness less than 3 m, but west of map area thickness is more than 500 m (Best, 1987)

Ti **Isom Formation (Oligocene)**—Reddish-brown to purple, crystal-poor, densely welded ash-flow tuffs and lava flows that weather to small plates and to grus. Phenocrysts generally constitute less than 15 percent of rock and include plagioclase and minor small pyroxene and Fe-Ti oxides. Tuffs contain vesicles and intensely compacted and locally elongated, distinctive and conspicuous gray pumice clasts. Published K-Ar dates for the Isom Formation range from 25.7 to 25.9 Ma, but more accurate bracketing dates by the $^{40}Ar/^{39}Ar$ method indicate that the Baldhills Tuff Member of the Isom Formation was erupted between 27.3 and 26.7 Ma (Scott and others, 1995). The younger Hole-in-the-Wall Tuff Member was erupted after 26.0 Ma. Thickness 140–190 m

Tnl **Lund Formation of Needles Range Group (Oligocene)**—Light-brown, reddish-brown, light-pink, and light-gray, partially to densely welded, dacitic ash-flow tuff. Phenocrysts of plagioclase make up about one-fourth of rock; lesser phenocrysts include quartz, biotite, hornblende, minor Fe-Ti oxides, and traces of sphene. Flattened, light-colored pumice lapilli are prominent in most outcrops, and lithic fragments are present. Age is 27.9 Ma (Best and Grant, 1987). At least 150 m thick, but base is not exposed. Nearest measured thicknesses are 400 m within the Indian Peak caldera complex just northwest of map area and 100 m outside the caldera complex just north of eastern part of map area (Best and others, 1989, fig. 5c)

Contact

High-angle dip-slip fault—Bar and ball on downthrown side where relative movement known. Arrow shows direction and dip of fault plane where known. Dashed where approximately located or inferred; dotted where concealed

Strike and dip of compaction foliation in welded tuff
- Inclined
- Vertical

Strike and dip of flow layering in lava flow
- Inclined
- Vertical

Strike and dip of joint

Fault-scarp measurement locality—Showing height (in meters) and slope (in degrees) of fault scarp formed in Quaternary deposits

Hydrothermally altered rocks along the Bible Spring fault zone

Drill hole

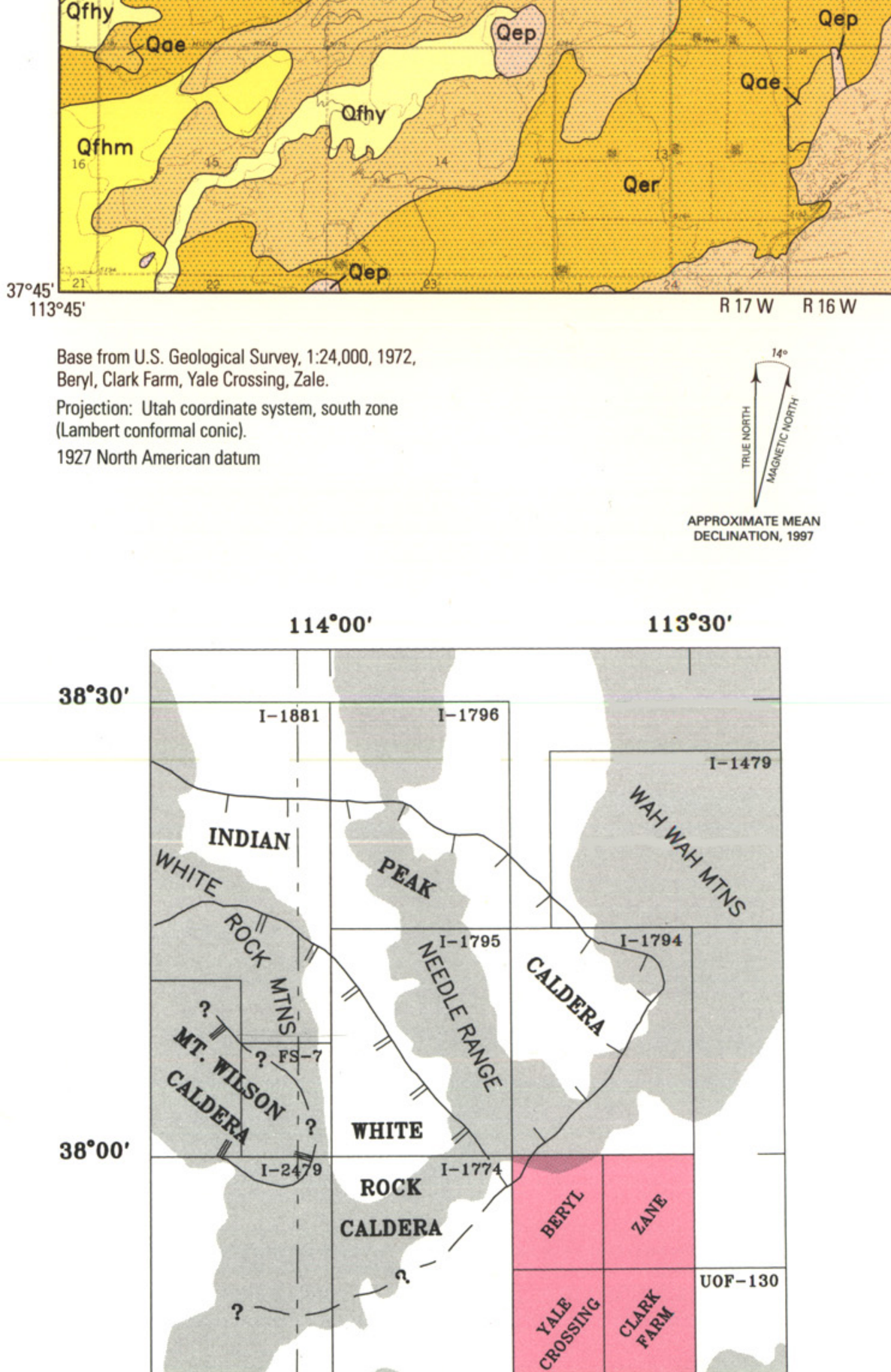

Figure 1. Index map showing published U.S. Geological Survey (GQ, I, MF, and OF series), Nevada Geological Survey (FS), and Utah Geological Survey (UGS) geologic maps, and selected geologic and geographic features (mountains shaded) in the vicinity of the map area (pink), southeastern Nevada-southwestern Utah. Much of the margin of the Indian Peak caldera complex, which includes the Indian Peak, White Rock, and Mt. Wilson calderas, is covered by deposits and is only approximately located (dashed line) from gravity data (Best, Christiansen, and Blank, 1989).

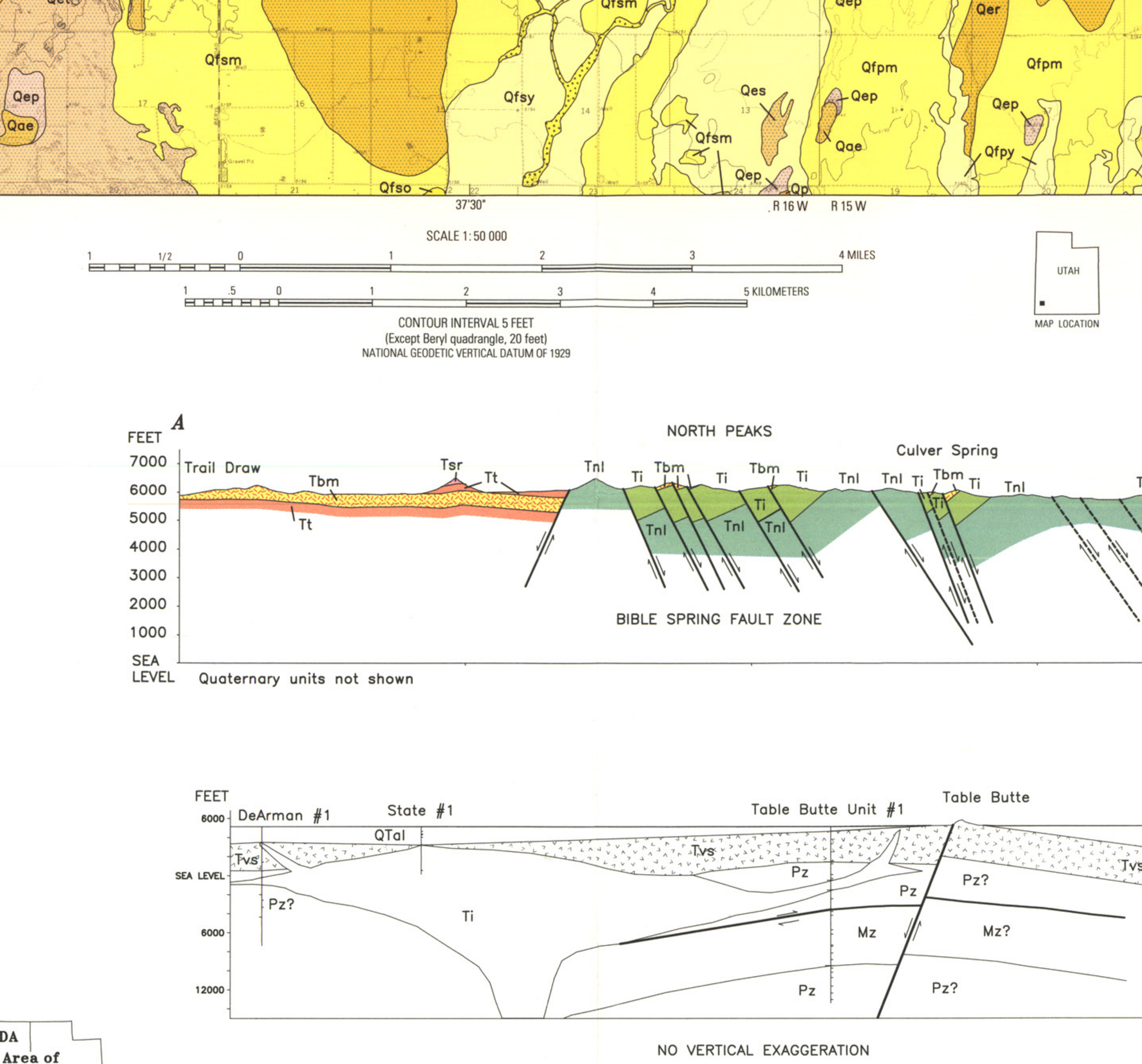

Figure 3. Diagrammatic cross section based on lithologic logs of the four drill holes shown in figure 2. Contacts shown in figures 4–7 are represented by ticks along the drill holes. The form of the intrusive and the dip of sedimentary beds is conjectural, and normal faults are probably much more abundant than shown. QTal, Quaternary and Tertiary alluvium; Tvs, Tertiary volcanic and sedimentary rocks; Ti, Tertiary intrusive rocks; Mz, Mesozoic sedimentary rocks; Pz, Paleozoic sedimentary rocks. Normal and thrust faults shown by heavy line; opposed arrows indicate relative movement.

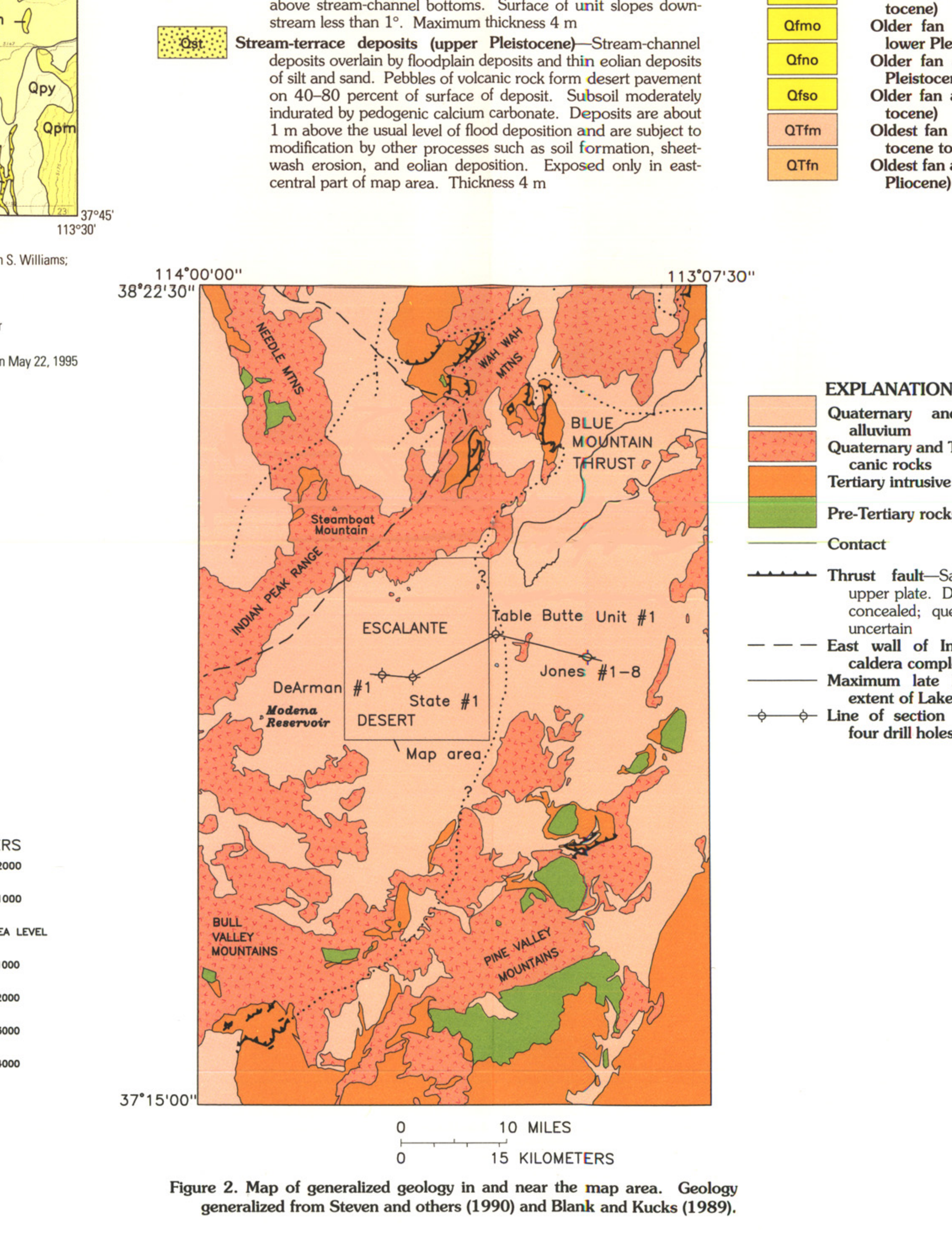

Figure 2. Map of generalized geology in and near the map area. Geology generalized from Steven and others (1990) and Blank and Kucks (1989).

GEOLOGIC MAP OF THE CENTRAL ESCALANTE DESERT AREA, IRON COUNTY, UTAH

By
Van S. Williams
1997

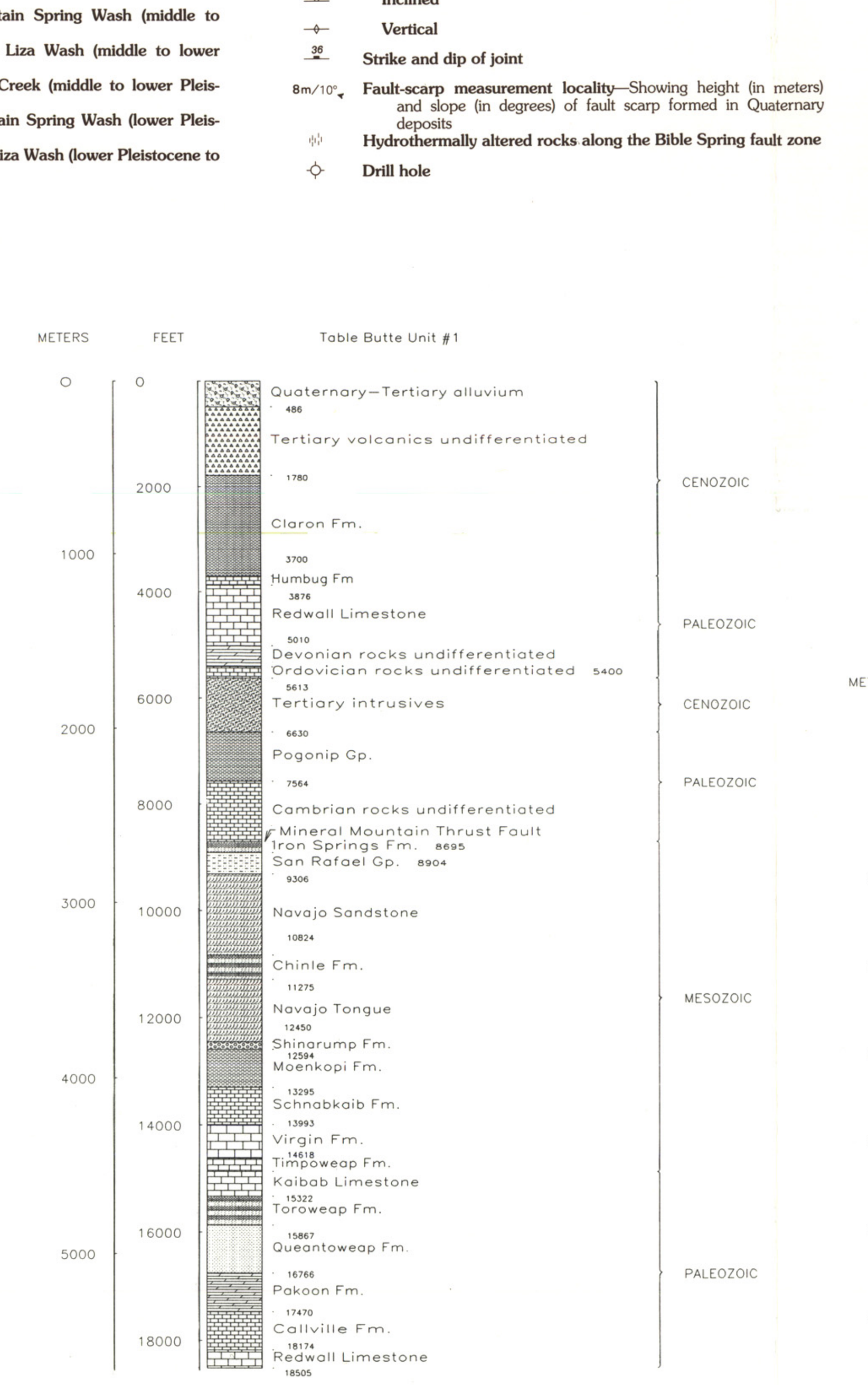

Figure 4. Stratigraphic log of Hunt Oil Company's Table Butte Unit #1 petroleum test hole as recorded in the records of the Utah Department of Natural Resources, Division of Oil, Gas, and Mining (written commun., 1984). The sequence of units recorded below the Navajo Sandstone and above the Shinarump Member of the Chinle Formation is probably incorrect. Small numbers on right side of log are depths of formation tops in feet. Collar elevation 5,102 ft (1,555 m).

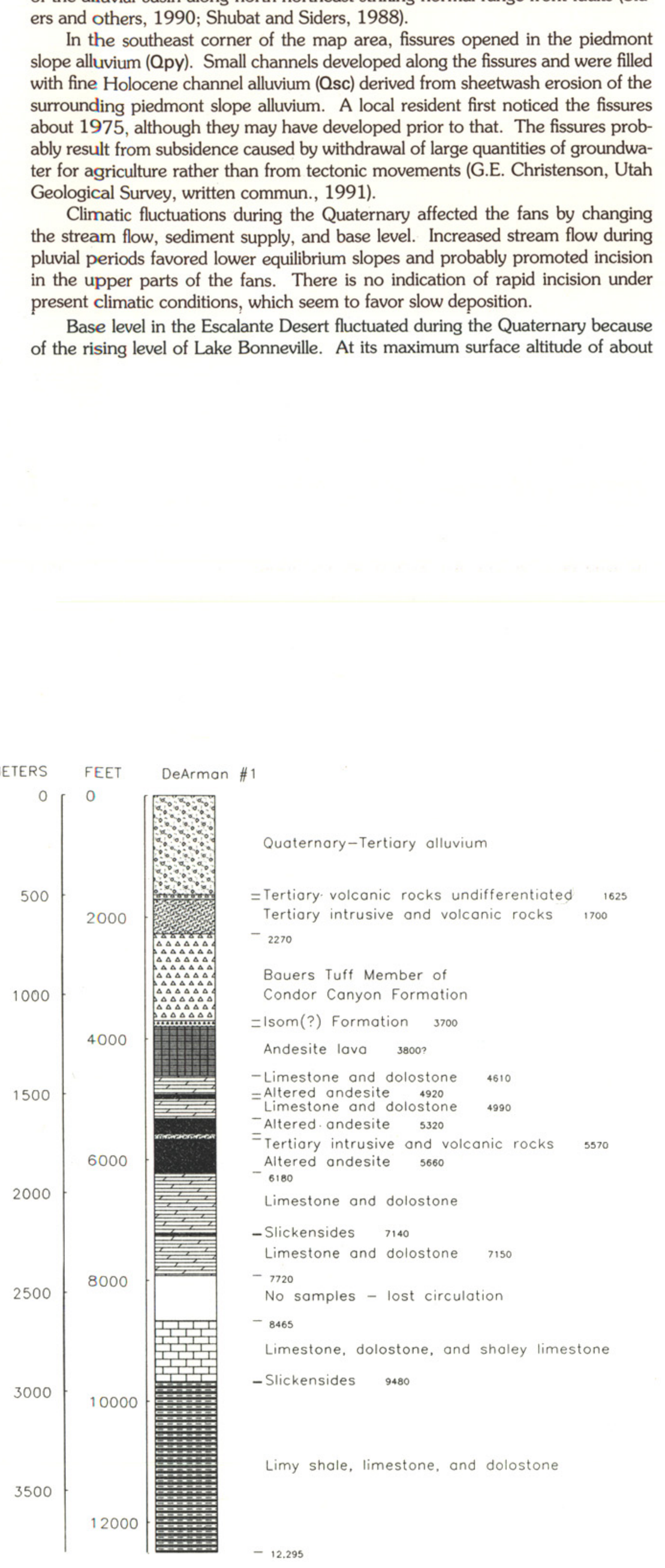

Figure 5. Lithologic log of Utah Power and Light's DeArman #1 geothermal test hole as described in Pe and Cook (1980) and modified according to reinterpretation of samples by M.G. Best (written commun., 1985). Small numbers on right side of log are depths of formation tops in feet. Collar elevation 5,138 ft (1,566 m).

DISCUSSION

Most of the map area is covered by Tertiary and Quaternary alluvial and eolian deposits that form the floor of the Escalante Desert (figs. 1, 2). Only a narrow band of Oligocene and Miocene volcanic rocks along the north edge of the map area, subsurface information from drill holes, and data from aeromagnetic and gravity surveys allow some insight into the pre-Quaternary history.

The most valuable subsurface information is provided by Hunt Oil Company's Table Butte Unit #1 drill hole (Hunt Oil Company, written commun., 1984), which was spudded just 1 km east of the map area in the northwest corner of sec. 36, T. 33 S., R. 15 W. (fig. 2) and extends to a depth of 5,640 m (figs. 3, 4). It penetrated 148 m of basin-fill alluvium, 979 m of Tertiary volcanic and sedimentary rocks, 310 m of Tertiary intrusive rocks, 1,880 m of Mesozoic sedimentary rocks, and 2,633 m of Paleozoic sedimentary rocks. The hole intercepts a major thrust fault (Mineral Mountain thrust?) of probable Sevier age at a depth of 2,650 m. This thrust places Cambrian rocks over the Upper(?) Cretaceous Iron Springs Formation. The hole bottoms in the upper part of the Redwall Limestone, which is also penetrated higher in the hole in the upper plate. The thrust fault in the center of the basin may be a continuation of similar faults exposed where Paleozoic and Mesozoic rocks are at the surface north and southwest of the map area (fig. 2). Pan Am Petroleum's fee well #1-B (Pe and Cook, 1980, p. 145), drilled just 2 km south of Table Butte unit #1, is not shown on figures 2 and 3 because it adds no useful information.

Two holes were drilled in the map area to explore for geothermal resources. DeArman #1 (sec. 18, T. 34 S., R. 16 W.; lat 37°50′20″N., long 13°41′11″W.) penetrated 495 m of basin-fill alluvium, 736 m of Tertiary volcanic rocks, 457 m of Tertiary intrusive rocks, and 2,059 m of carbonate sedimentary rocks, probably of Paleozoic age (fig. 5) (Pe and Cook, 1980, p. 139). Slickensides in the lower part of the hole indicate faulting, but without good stratigraphic control the faulting might be normal faulting (such as is common in surface exposures), faulting related to emplacement of the intrusive rocks, or Sevier thrust faulting.

The State #1 drill hole, near the center of the map area (sec. 22, T. 34 S., R. 16 W.; lat 37°50′08″N., long 113°37′54″W.), penetrated 576 m of basin-fill alluvium, 5 m of Tertiary volcanic and intrusive rocks, and 833 m of fractured Tertiary quartz monzonite (fig. 6) (Pe and Cook, 1980, p. 141). This is the greatest thickness of Tertiary intrusive rock encountered in the three holes near the map area, and the only place where the base of the intrusion was not penetrated. Similar quartz monzonite rocks are not exposed at the surface within the map area, but crop out only 120 m east of the map boundary and 5 km south of the Table Butte Unit #1 drill hole (fig. 2) (Grant and Proctor, 1988). It seems likely that most of the southern part of the map area is underlain by extensive Tertiary intrusions, the upper part of which may be locally concordant with sedimentary country rocks. Figure 2 shows areas north and south of the map area where similar Tertiary intrusions are exposed at the surface.

The Jones #1-8 geothermal test well, east of the map area (sec. 8, T. 34 S., R. 13 W.; lat 37°51′51″N., long 113°19′58″W.) (figs. 2, 3, 7), penetrated 893 m of basin-fill alluvium and 856 m of interbedded Tertiary volcanic and sedimentary rocks, but did not penetrate any intrusive rocks (M.G. Best, written commun., 1985; Pe and Cook, 1980). It does indicate that volcanic rocks near the center of the basin east of the map area were downdropped more than those within the map area.

During the Eocene, the map area and its surroundings apparently subsided and calcareous siltstone and sandstone of the Claron Formation were deposited. During the Oligocene and middle Miocene, the area was covered repeatedly by ash-flow tuffs from the Indian Peak caldera complex to the northwest and the Caliente caldera complex to the southwest. The southeast boundary of the Indian Peak caldera complex is covered but is inferred to pass through the northwest corner of the map area (Best and others, 1989). The Indian Peak caldera complex was active from 33 to 26 Ma and was the source of the Lund Formation, the thickest unit exposed in the map area (Best and others, 1993).

STRUCTURE

The volcanic rocks exposed along the northern edge of the map area are deformed by at least two intersecting sets of normal faults. One set, which was active after 23 Ma and before 13 Ma, strikes north to north-northeast, dips about 60° E., and repeatedly offsets a section of Blawn Formation (Tbm), Isom Formation (Ti), and Lund Formation (Tnl). The total estimated offset along seven parallel east-dipping faults in cross section A–A′ exceeds 1,900 m and ranges from 5 to 600 m on individual faults. Some of the east-dipping faults in the central part of section A–A′ may be a continuation of the Bible Spring fault zone mapped to the north (Best, 1987). Rocks along those faults have locally been altered and bleached by hydrothermal fluids.

The younger set of faults, active since about 10 Ma, strikes east-northeast and dips about 70° S. This set offsets the older set and the Steamboat Mountain Formation, as well as older volcanic rocks. The younger set defines the range front and is probably related to a gentle southward flexure that bends the rock layers down beneath the alluvial fill of the Escalante Desert floor. The Isom Formation is 1,270 m lower in the DeArman #1 drill hole than in its lowest outcrop, indicating an average dip of about 5° S.

A still younger north-northeast-striking fault dips southeast and offsets lower to middle Pleistocene alluvium in the northeast corner of the map area. The fault disappears beneath eolian deposits and basin-fill alluvium to the southwest, but extends 8 km northeast from the edge of the map area, where it connects with range-front faults. Two small earthquakes were recorded along the fault (Goter, 1990), but there is no evidence of recent surface rupture. The maximum scarp slope of 10° relative to the maximum scarp height of about 8 m is much lower than the average for 15-ka Lake Bonneville shoreline scarps reported by Bucknam and Anderson (1979), indicating that the scarp was probably formed before the late Pleistocene.

Gravity data indicate a probable basement ridge passing beneath the map area from the center of the southern map edge to the center of the eastern map edge, near Table Butte. A northeast-trending structural basin extends approximately from the southwest to the northeast corners of the map area (Blank and Kucks, 1989). Neither gravity nor aeromagnetic data indicate any strong signature for the intrusions observed in the drill holes, which suggests that they are relatively thin sills and laccoliths rather than batholithic bodies.

GEOMORPHOLOGY

Most of the map area is covered by fan alluvium deposited by streams draining the mountains and hills that form the perimeter of the Escalante Desert. The fans of Mountain Spring, Negro Liza, and Fourmile Washes, which drain from the north, are smaller and steeper than the fan of Hogans Wash, which drains from the west, and the fans of Shoal Creek and Pinto Creek, which drain from the south. For example, Mountain Spring Wash has a gradient of about 7.6 m/km, whereas the average gradient of Shoal Creek in the map area is about 1 m/km.

Episodic incision of streams on all the fans has left large areas that no longer receive deposits of sediment from trunk streams. These incised areas are either eroded by, or receive sediment from, sheetwash and small streams that rework the surface of the fans. Mountain Spring Wash fan is incised 8 m near its head, whereas Shoal Creek fan is incised less than 1 m at the south edge of the map area and 3 m near its head 15 km to the south. Thick, calcium carbonate-enriched soils have developed on parts of the fan surfaces that have not received significant trunk stream deposition for long periods. Four ages of fan surfaces are recognized based on geomorphic position, dissection, and soil development, but the age relations of different fan surfaces are obscured on the fans from the south and west because of extensive eolian reworking of the surface sediment, very low slopes, and lack of deep dissection. The two fans from the north are clearly segmented (Bull, 1964; Hooke, 1968). Radial profiles from the heads to the toes of the fans consist of a series of straight-line segments decreasing in slope downstream, rather than a smooth curve. This form has developed because the center of deposition has moved downstream episodically through time, and either the depositional slope has become more gentle, or older surfaces were tilted toward the basin and partially buried by younger surfaces.

The cause of periodic fan incision is probably a combination of tectonic, climatic, and geomorphic factors. Subsidence of the Escalante Desert basin relative to the surrounding mountains is documented by drill-hole data and the dips of beds in isolated exposures south of the mountain front. Continuation of subsidence is indicated by 4 m of incision of the Fourmile Wash fan that was caused by Quaternary faulting. Elsewhere in the map area there are no scarps, and flexure toward the basin axis is the most probable tectonic mechanism in the northern part of the map area. About 2 km southeast of the southeast corner of the map area, down-to-the-west Quaternary scarps indicate continued tectonic subsidence of the alluvial basin along north-northeast-striking normal range-front faults (Siders and others, 1990; Shubat and Siders, 1988).

In the southeast corner of the map area, fissures opened in the piedmont slope alluvium (Qpy). Small channels developed along the fissures and were filled with fine Holocene channel alluvium (Qsc) derived from sheetwash erosion of the surrounding piedmont slope alluvium. A local resident first noticed the fissures about 1975, although they may have developed prior to that. The fissures probably result from subsidence caused by withdrawal of large quantities of groundwater for agriculture rather than from tectonic movements (G.E. Christenson, Utah Geological Survey, written commun., 1991).

Climatic fluctuations during the Quaternary affected the fans by changing the stream flow, sediment supply, and base level. Increased stream flow during pluvial periods favored lower equilibrium slopes and probably promoted incision in the upper parts of the fans. There is no indication of rapid incision under present climatic conditions, which seem to favor slow deposition.

Base level in the Escalante Desert fluctuated during the Quaternary because of the rising level of Lake Bonneville. At its maximum surface altitude of about 1,553 m (Currey and Oviatt, 1985), Lake Bonneville probably extended to within 5 km east of the northeast corner of the map area, and the lowest parts of the map area may have become marshy. The meandering pattern of some dry stream channels in the east-central part of the map area may be a relict of that period. The rare flash floods that provide the only flow in those channels under the present climate are more likely to produce a braided pattern. Present local base level for the map area is a playa at an altitude of 1,550 m about 5 km east of the north edge of the map area, so the maximum base level change during the late Pleistocene was only 3 m.

Anderson and Bucknam (1979) described possible shorelines at Table Butte near the center of the Escalante Desert at an altitude of 1,584 m, which is above most of the map area and above the generally accepted maximum altitude of Lake Bonneville. No deposits or landforms in the map area indicate submergence by a lake during the late Pleistocene, but thick deposits of clay and fine silt in drill holes (Mower and Sandberg, 1982; Mower, 1981) suggest that lacustrine conditions may have occurred in the early Pleistocene or Pliocene.

Stream capture in the headwaters of Mountain Spring and Negro Liza Washes, north of the map area, also contributed to incision of fan deposits in the Escalante Desert. The alluvium-filled, closed basin of Pine Valley was breached, and rapid headward erosion of Mountain Spring Wash is expanding the northern part of the drainage area tributary to Mountain Spring Wash alluvial fan. Equilibrium slope varies inversely with a power function of drainage area (Bull, 1964), so increase in drainage area would tend to cause incision in the upper part of the fan and deposition near the toe.

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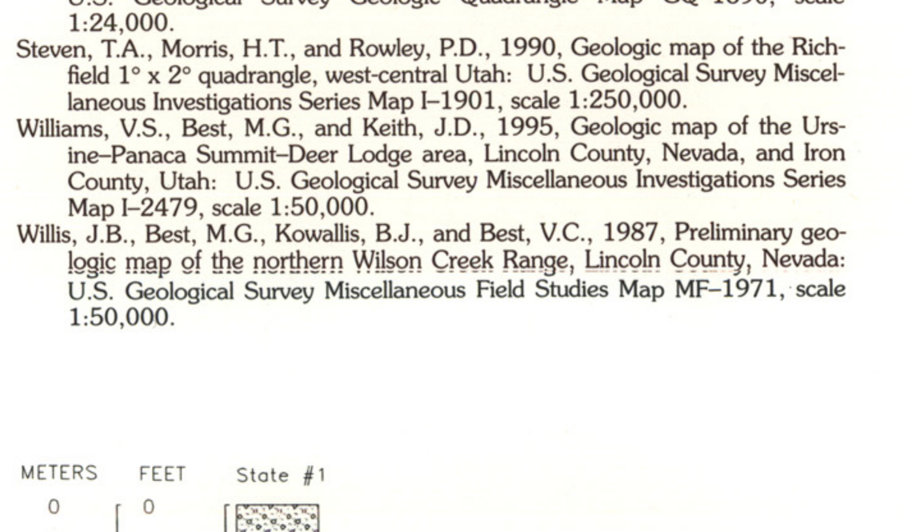

Figure 6. Lithologic log of Utah Power and Light's State #1 geothermal test hole as described in Pe and Cook (1980). Small numbers on right side of log are depths of formation tops in feet. Collar elevation 5,128 ft (1,563 m).

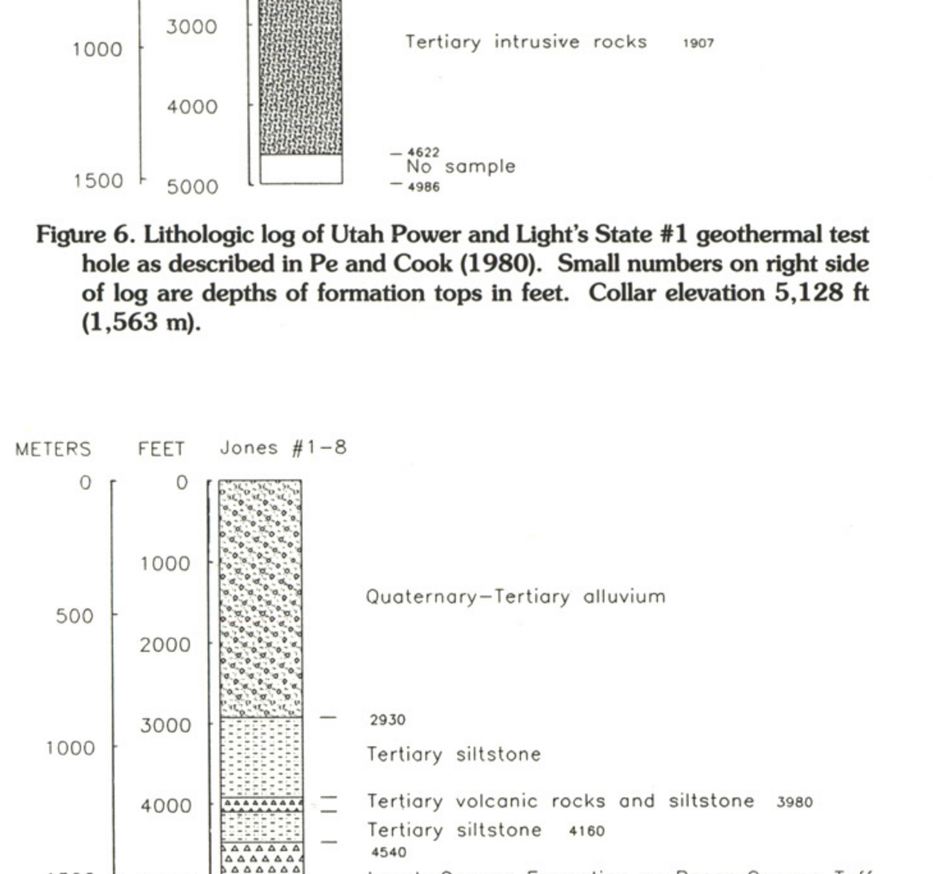

Figure 7. Lithologic log of Geothermal Kenetics, McCulloch Oil, and Utah Power and Light's Jones #1-8 geothermal test hole as described in Pe and Cook (1980) and modified according to reinterpretation of samples by M.G. Best (written commun., 1985). Small numbers on right side of log are depths of formation tops in feet. Collar elevation 5,199 ft (1,585 m).

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